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IS TYPHOID FEVER CONTAGIOUS?

Typhoid fever is one of the most common of the serious ailments of civilised life. No household is safe against it; there is no family which it may not invade. In Great Britain alone not much short of 200,000 people suffer from it every year. Of these nearly 20,000 die, most of them in the prime of life. It is even more prevalent on the Continent.

The question of the contagiousness of such a disease is one of vital importance; and yet it is one on which the most antagonistic opinions are held.

Among the many ailments which may be transmitted from the sick to the healthy, the ones with which we are most familiar in this country, are those which are grouped together under the name of 'the eruptive fevers.' To this group typhoid fever belongs. It includes also small-pox, typhus fever, scarlet fever, and measles. Each consists of an attack of fever of more or less definite duration, and of a local inflammation or eruption: during the course of each its poison is largely reproduced in the system; and each may be transmitted from the sick to the healthy.

There are several ways in which a disease may be transmitted.

1. Its poison may be introduced directly by inoculation, as is daily done in the case of vaccination.

2. It may pass directly into the surrounding atmosphere from the persons of the sick, and be inhaled by those in their neighbourhood, as constantly happens in small-pox, typhus fever, measles, and scarlet fever.

3. It may be conveyed indirectly, and to a distance, in articles of clothing, bed linen, etc., and, passing from them, may be inhaled by those who wear or handle them, as often happens in the same diseases. Or it may be conveyed in food or water, and enter the system through the digestive organs, as frequently happens with the poison of typhoid fever.

When we wish to say that a disease is transmitted from person to person, without defining the mode of transmission, we say that it is communicable. The term is a general one which includes every mode of transmission.

When we wish to say that a disease may be transmitted by inoculation, we say that it is INOCULABLE.

When we wish to say that the poison may be conveyed in articles of clothing, in linen, in food, in water, etc., we say that these articles have been infected by the poison, and that the disease is INFECTIOUS.

When we wish to say that a disease is produced by personal contact with one suffering from it, and that the danger of catching it increases with the closeness and intimacy of such contact, we call it CONTAGIOUS.

A contagious disease, therefore, is one in which the danger of contracting it increases as we approach, and diminishes as we recede from, a person suffering from it. It is *contactuous*.

Contagion may be defined as direct infection; and infection as indirect contagion. In both a poison passes from the sick to the healthy. It is the difference in the mode of conveyance of the poison that makes the difference between the two. The distinction is one of the utmost practical importance, and must be borne in mind in discussing the question of the contagiousness of any disease. An ailment may be infectious without being contagious.

In science, precision of language is of as much importance as accurate observation. It is the want of this precision which has led to the diversity, nay the antagonism, of opinion which prevails among the highest authorities on the question of the contagiousness of typhoid fever. M. Piedvache, the chief Continental advocate of that doctrine, uses the word contagious as if it were synonymous with communicable: 'J'emploierai le mot contagion dans sa signification la plus étendue, designant sous ce nom toute transmission de la maladie d'un individu malade à un individu sain, quelque soit la mode suivant laquelle elle s'opère.' Dr. Budd, its great English advocate, uses the word in exactly the same sense; and gives as instances of the contagiousness of the disease, cases in which the second sufferer had never even been in the same house as the first. This is an inaccurate use of the word: from a scientific point of view, the severest judgment that could be pronounced against it. But it is also inaccurate and misleading from a popular and colloquial standpoint. When, with reference to a case of typhoid fever in his own house, a man asks the question 'Is it contagious?' he does not wish to know whether or not some one in the next street may take the disease, but whether or not there is a likelihood of its spreading among the members of his own household, and whether or not there is danger in going near the sufferer. The only accurate and proper meaning of the word is that attached to it in the definition which I have given. That, therefore, is the sense in which it is used in this paper.

What is the nature of the poisons which pass from the sick to the healthy? Their most distinctive peculiarity is that they are largely reproduced in the system during the course of the maladies to which they give rise. The minutest possible portion of small-pox matter, for instance, may be introduced into the system of a person who has not had that disease, and who has not been vaccinated, with the certainty of giving rise to a malady during whose course there will be formed many thousand times as much of the poison as sufficed to set the disease agoing. All that is introduced may be just so much small-pox matter as adheres to the point of a needle dipped into it. The resulting disease may be characterised by an eruption of thousands of pustules, each containing many times as much of the poison as rested on the needle point. So it is with all diseases which spread from the sick to the healthy; during their course the poisons which give rise to them are largely reproduced in the system. In connection with no ordinary poisonous or medicinal agency is the same thing noted. Many of these are eliminated from the system in the same form in which they enter it; but in not one does the quantity eliminated exceed that received.

This power of reproduction is peculiar to, and distinctive of, organised structures, animal and vegetable. There is no physical or chemical process at all identical with it. There is nothing in nature identical with it, except that power of reproducing their kind with which all living organisms are endowed. The poisons reproduced during the diseases with which we are now dealing, are also true to their kind, another distinctive feature of organised structures. As surely as an acorn produces only an oak, and a rose-seed only a rose-tree; as surely as every animal produces an offspring identical with itself; so surely does typhus give rise only to typhus, measles only to measles, and every other allied disease only to its own special poison and malady.

This power of development, and this faculty of breeding true, show that the poisons of these diseases consist of minute organisms or germs. There is no other adequate explanation of these phenomena; and it is now very generally admitted that such is their real nature.

This view serves also to explain phenomena noted in connection with admittedly contagious diseases, which are quite inexplicable on the old, and still popular, view that the poison consists of a gaseous or vapoury emanation. Germs are minute solid particles. It has been proved by M. Chauveau and Dr. Burdon-Sanderson, that the poisons of cow-pox and sheep-pox (the analogues in these animals of small-pox in man) consist of such particles. From the fact that the microscope fails to detect these particles in fluids known to contain them, we infer that they are less than $\frac{1}{50000}$th of an inch in diameter, that being about the ordinary limit of human vision. That the atmosphere habitually contains particles so minute that the highest powers of the microscope fail to demonstrate their existence, has been proved by Professor Tyndall.[1]

Contagion, then, consists physically of minute solid particles. The process of contagion consists in the passage of these from the bodies of the sick into the surrounding atmosphere, and in the inhalation of one or more of them by those in the immediate neighbourhood. If contagion were a gaseous or vapoury emanation, it would be equally diffused through the sick-room, and all who entered it would, if susceptible, suffer alike and inevitably. But such is not the case; for many people are exposed for weeks and months without suffering. Of two persons situated in exactly the same circumstances, and exposed in exactly the same degree to a given contagion, one may suffer, and the other escape. The explanation of this is that the little particles of contagion are irregularly scattered about in the atmosphere, so that the inhalation of one or more of them is purely a matter of chance, such chance bearing a direct relation to the number of particles which exist in a given cubic space. Suppose that a hundred germs are floating about in a room containing two thousand cubic feet of air. There is one germ for every twenty cubic feet. Naturally the germs will be most numerous in the immediate neighbourhood of their source, the person of the sufferer; but, excepting this one place, they may be pretty equally distributed through the room; or they may be very unequally distributed. A draught across the bed may carry them now to one side, now to the other. The mass of them may be near the ceiling, or near the floor. In a given twenty cubic feet, there may be a dozen germs, or there may be none at all. One who enters the room may inhale a germ before he has been in it ten minutes; or he may remain there for an hour without doing so. Double the number of germs and you double the danger. Diminish the size of the room by one half, and you do the same. Keep the windows shut, and you keep the germs in; open them, and they pass out with the changing air. Hence the importance of free ventilation; and hence one reason why fever should be treated, if possible, in large airy rooms. Not only is free ventilation good for the sufferer, but it diminishes the risk to the attendants.

We see in this, too, the reason for banishing bed-curtains, carpets, and all unnecessary furniture from the sick room in cases of contagious fever. The germs are apt to adhere to such articles, and so make them the means of conveying the disease to others.

The explanation of the varying extent to which those who are equally susceptible and equally exposed, suffer from the action of these poisons, is the same as that which applies to a regiment in action. If the contagion were as diffusible as the gases formed in the explosion of the powder, all those exposed to it would soon be placed *hors de combat*. But just as in battle it is not the explosion of the powder, but the bullet which is impelled, that is deadly to the soldier, so in contagious fevers, it is not the vapoury emanations from the lungs and skin of the sufferer which are deadly to those around, but the contagious particles which are given off with them. And just as some soldiers are killed in their first battle, while others go through many campaigns without receiving a scratch, so some persons take typhus or scarlet fever after a single exposure, while others may be exposed for months before they suffer, and may even escape altogether.[2]

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[1] *Transactions of the Royal Society*, part i., 1876.

All organisms consume in their growth nitrogen and water. Those with which we are now dealing are no exception to the rule. Growing in the system, they must get these elements there. But nitrogen and water are the chief materials required for the nutrition and repair of the various organs and tissues of the body. The propagation in it of millions of organisms having wants identical in the main with those of its own tissues, must cause serious disturbance. And so it does. This disturbance declares itself by that aggregate of phenomena to which we apply the term fever.

An organism which thus grows in and at the expense of another, is a parasite. One of the peculiarities of parasites is that they flourish, not in any part of their host, but only in some particular organ or tissue, which is called the *nidus*, or nest of the parasite. Each has its own special nidus. This one grows in small intestine, that in large; this in skin, that in mucous membrane; this in liver, that in kidney; this in brain, that in muscle. The organisms with which we are now dealing (the poisons of the eruptive fevers) show similar peculiarities. Each has its own nidus, its own localised habitat, in which it is propagated, and out of which it ceases to be reproduced. The poison of small-pox has its nidus in the deep layer of the skin; hence its characteristic eruption. That of scarlet fever in the superficial layer of the skin, and in the throat; hence the rash and the sore-throat of that disease. That of measles in the skin, and in the mucous membrane of the air-passages; hence its characteristic symptoms. That of typhoid fever in the glands of the intestine; hence that disease consists of fever, and of ulceration of the bowel.[3]

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[2] The view that germs play an important part in the production of diseased processes, and especially in the production of those which are the cause of so much fatality after surgical operations, led Mr. Lister to adopt the method of treatment with which his name is associated. This antiseptic treatment, as it is called, simply consists in so performing operations, and in so dressing wounds, that it is impossible for germs to get into them. The simple precaution of excluding the germs which are constantly floating about in the atmosphere, and which Mr. Lister's keen insight and scientific mind led him to regard as the cause of those disastrous consequences which made surgical operations so fatal, —this simple precaution has led to one of the greatest advances in modern surgery, and to the saving of many a life which would otherwise have been sacrificed.

[3] It is very generally supposed that the eruptions of small-pox, measles, scarlet fever, and typhus fever, as well as the bowel lesion of typhoid fever, result from nature's efforts to eliminate the poisons of these diseases from the system. Did

The contagiousness of a given eruptive fever must be directly as the number of germs which, in a given time, pass from the body of a sufferer into the surrounding atmosphere. This, in its turn, must depend on the seat of the propagation of the poison, and on the relation which this bears to that atmosphere. In small-pox, scarlet fever, typhus fever, and measles, the seat of this propagation is the skin and mucous membrane of the air-passages; it is, therefore, in direct, free, and constant communication with the external air. The poisons of these diseases are accordingly freely given off into the atmosphere of the room in which the sufferer is, and they themselves are highly contagious.

In typhoid fever, the poison is propagated in the bowel, and is thrown off with the discharges from it. It thus passes from the system in a manner, and in a combination, which ensure its speedy removal from the neighbourhood of the sufferer. The typhoid germs are there; but they are mingled with discharges which may be removed, and as matter of course are removed, before the germs can pass off from them into the surrounding atmosphere. The seat of the propagation of the typhoid poison has no direct relation with this atmosphere; germs cannot pass directly from the one to the other; the disease, therefore, does not display the property of contagiousness.

The danger in typhoid fever is not contact with the person of the sufferer, but contact with his stools. If these are properly managed and disposed of, the disease can scarcely spread. But if they are allowed to pass into drains which are imperfectly trapped, inadequately ventilated, or insufficiently flushed; or if they are carelessly thrown on the ground, or allowed to percolate through the soil into drinking water, then one case of typhoid fever may give rise to many others. The occurrence of a case of typhoid fever in a house is a sharp test of the efficiency of its sanitary arrangements. If these are perfect, and the stools properly managed, all will go well; if they are defective, one case may give rise to many others. But the communication of the disease is not direct, by contact; it is indirect, by infection of drinking water, or of an atmosphere which may be remote from the person who is the source of the poison. A case of typhoid fever is introduced into a locality. The stools are thrown out on the ground or into a cesspool, whence they percolate through the soil into a well. The person who drinks water from that well

nature possess the wisdom and the power to make such an effort, she would better exemplify her wisdom, and more efficiently use her power, by bringing the latter into operation at an early period of the illness, when the poison exists in small quantity, and when it might be got rid of, not only more easily, but before it had so increased as to imperil the safety of its victim. These lesions are really the result of the action which, in each of these fevers, takes place during the propagation in its nidus of the organism which causes the disease. The passage outwards of the germs is in each case the physical and inevitable result of the situation of the lesion.

runs a greater risk than one who sleeps in the same room as the sufferer, and is in constant attendance on him.

The practical outcome of all this is (1), that the mother may nurse her son, the wife her husband, the sister her brother, without the risk involved in the case of typhus or scarlet fever; and (2), that there is little or no danger to the other inmates of the house, if its sanitary arrangements are perfect, and the stools properly managed.

On this view of the nature and mode of action of contagion, it is easy to see, not only how the process of contagion and its varying phenomena may be explained, but how, by care, much may be done both to prevent the poison from passing into the atmosphere, and to diminish its chance of acting after it has got there. We have only to consider what is the chief channel by which the contagion gets exit from the system, to know by what means we are most likely to prevent its passing into the surrounding atmosphere. In typhoid fever the poison passes off in the stools; and what we have to do is to see that these are promptly and properly disinfected and disposed of. In small-pox, scarlet fever, typhus fever, and measles, it is eliminated by the skin, and we cannot altogether prevent its getting into the atmosphere; but by frequent sponging with some disinfecting fluid, or even with plain water, many germs may be arrested in their outward course.

The apostolic mode of anointing with oil is also an efficacious way of fixing and arresting the germs: it is specially useful during convalescence from scarlet fever in fixing the particles of peeling skin, which are a source of much danger. They are dangerous because they contain the germs which have been produced in them. What we see happen in the larger particles of skin happens also in many of the much smaller particles of contagion.

By the adoption of these various measures, by rigorously isolating the sufferer, and by having the room well ventilated, much, very much may be done to check the spread of contagious fevers. The matter of which organisms are composed is one of the most perishable things in nature. Contagion is no exception to the rule. By exposure to the air much of it is destroyed; hence such exposure is one of the best of all disinfectants. For one germ that comes to maturity, thousands perish. It is the same throughout Nature; for one acorn that produces an oak, for one rose seed that developes into a rose tree, for one ovum that developes into an animal, many thousands die. In her arrangements for ensuring the continuance of a species, Nature is almost wantonly lavish. In her arrangements for keeping its numbers within proper bounds, she is equally provident.

Sanitary science has done much to show us how some of the diseases with which we are now dealing might be extinguished, and how all of them might have their prevalence greatly diminished. It rests with those who have such ailments in their houses to carry into effect the measures calculated to destroy and get rid of the poison, before it has had time or opportunity to be a source of danger to those around. But the adoption of proper measures presupposes a knowledge of the nature of the poison with which we have to deal, and of the manner in which it passes off from the system. In not one is this knowledge more necessary than in typhoid fever; in not one are the measures which such knowledge dictates more easily applied, or more likely to be effective. But to regard typhoid fever as contagious in the sense that small-pox and typhus fever are so, is to divert attention from the true source of danger, to lead to the adoption of measures which are uncalled for, to the neglect of those which are urgently required; is to cause unnecessary concern to the sufferer and his friends, and to deprive him and them of the mutual comfort and solace which a little daily intercourse affords. The peculiarities of the illness may be such as to make it right to exclude the friends; but isolation is not requisite for the same reason that it is so in typhus.

One more point. The receiver as well as the giver of the poison has something to do with the determination of its action. Not every person into whose system a germ passes necessarily suffers from its action. A man who has had small-pox, for instance, is no longer susceptible to the action of its poison,—and why? Not because the poison cannot get into his system, for we can make sure of that by inoculating him with it, but because, during the first attack, the nidus, the special material necessary to its propagation, was exhausted, and has not been reproduced. This immunity from a second attack is a general characteristic of the eruptive fevers; individual exceptions there are, but the rule is that one attack confers immunity from a second.

A germ does not act unless it reaches its nidus; it may enter the system, make the round of the circulation, and again pass out without ever coming in contact with its nidus, and therefore without doing harm. The more widely the nidus is diffused, the less likely is this to happen. In small-pox, in scarlet fever, and in measles, the nidus is widely scattered. In none of them is a germ likely to make the round of circulation more than two or three times, without being conveyed to its nidus.

In typhoid fever the nidus is situated in a limited portion of the bowel, the sole route to which, by way of the circulation, is through an artery the size of a crowquill; a typhoid germ may be taken in through the lungs, and may make the round of circulation two or three dozen times, without being likely to enter that particular vessel. The more often this may occur, the greater the chance of its being thrown off from the system without acting. But if the typhoid germ be taken in through the digestive organs, it is brought into direct contact with the seat of its nidus, and can scarcely fail to act.

Hence the great danger of drinking water or milk contaminated with the typhoid poison. Milk is more dangerous than water under these circumstances, because so much of the water is boiled before it is used, and because the water requires no digestion, but passes directly into the circulation from the stomach, and unless there is food in the stomach, may carry the typhoid germs with it into the circulation, where they have the same small chance of reaching their nidus that they have when inhaled through the lungs. Milk, on the other hand, requires digestion, and the germs mingled with it are more likely to be carried down the digestive canal to the seat of their nidus.

The glands which constitute this nidus are not equally prominent and active all through life. In infancy they are quite rudimentary. At two or three they begin to grow, and gradually increase in size, and presumably in functional activity, till the age of puberty. They continue to be very distinct for twenty or twenty-five years. After forty they begin to get less, and gradually diminish till at seventy they have dwindled away so much that they can no longer exercise any active function. Their period of prominence and of functional activity corresponds exactly to the period of susceptibility to the action of the poison of typhoid fever. That disease is extremely rare in infancy; from two to six, or seven, it is more common, but is generally very mild. At fifteen or sixteen commences the period of greatest liability to it; and from that age on till thirty-five and forty it is very common, and very fatal. After forty-five it begins to decline both in frequency and severity; and goes on declining as years advance, till at seventy the liability to it may be regarded as practically worn out. When it occurs in advanced life it is generally mild; but its occurrence then is as rare as in infancy. Increased and diminished susceptibility to the action of the poison of typhoid fever correspond exactly to the increase and diminution in the size and functional activity of the glands which constitute its nidus. A rich nidus means a rich field for the propagation of the poison, and a correspondingly severe attack of the disease. A poor nidus means a poor soil, a scanty growth of germs, and a mild attack.

When the nidus is exhausted, the propagation of the germs ceases, and the disease comes to an end. The insusceptibility to the action of the poison, which is naturally and slowly developed in old age, is artificially and rapidly produced by the destruction of the nidus during an attack of the disease.

Using the word contagious in its proper sense of communicable by contact, and regarding the typhoid poison as a parasite whose nidus is in the glands of the bowel, we are led to the conclusion that the disease to which it gives rise, though undoubtedly infectious, can scarcely be contagious. We know from our experience that it is not so; for it never spreads in hospitals, and attendants on the sick suffer no more than other people.

The difficulty has been to reconcile these facts with the reproduction of the poison in the system. The source of this difficulty is the rooted belief that this reproduction takes place in the blood. On this view all the eruptive fevers ought to be equally contagious. But let us once adopt the view that the poisons of the eruptive fevers are parasites, and that the seat of the local lesion of each is the nidus of its parasite, and therefore the seat of its propagation, and the whole difficulty vanishes. We at once see why each has a definite period of duration, why one attack protects against a second, why each has its own characteristic lesion, why each presents such varying degrees of severity, and why they possess different degrees of contagiousness.

There is not one of the phenomena of the eruptive fevers which is not adequately explained on this theory. There can be no stronger argument in favour of any theory than that it is competent to explain all the phenomena which it is intended to elucidate.[4]

T. J. MACLAGAN.

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[4] Those interested in the question, and desirous of more detailed information egarding it, are referred to a work on *The Germ Theory of Disease*, written by myself, and published by Macmillan and Co. in 1876.